ELECTRIC FIELD STUDY OF SILICON RUBBER INSULATOR USING FINITE ELEMENT METHOD (SLIM)

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ABSTRACT

Silicone rubber provides an alternative to porcelain and glass regarding to high voltage (HV) insulators and it has been widely used by power utilities since 1980's owing to their superior contaminant performances. Failure of outdoor high voltage (HV) insulator often involves the solid air interface insulation. As result, knowledge of the field distribution around high voltage (HV) insulators is very important to determine the electric field stress occurring on the insulator surface, particularly on the air side of the interface. Thus, concerning to this matter, this project would analyze the electric field distribution of energized silicone rubber high voltage (HV) insulator. For comparative purposes, the analysis is based on two conditions, which are silicon rubber insulators with clean surfaces and silicon rubber insulators with contamination layer taking place over its surfaces. In addition, the effect of water droplets on the insulator surface is also included. The electric field distribution computation is accomplished using SLIM software that performs two dimensions finite element method. The finding from this project shows that pollution layer distort the voltage distribution along the insulator surface while different pollution layer material and variation in zone of incidence would contribute different profile of electric field. Existence of water droplets would create field enhancement at the interface of the water droplet, air and silicon rubber material. Also, the intensification field created by water droplet is depending on the droplets size, number of droplets and the proximity of water droplets to each other.

ABSTRAK

Getah silikon memberikan alternatif kepada porselin serta kaca yang digunakan sebagai penebat voltan tinggi dan ia telah digunakan secara meluas oleh pembekal kuasa semenjak 1980-an memandangkan prestasinya yang baik semasa kehadiran bahan pencemar. Kegagalan penebat voltan tingi di kawasan terbuka pada kebiasaannya melibatkan bahagian di sempadan penebatan antara udara dan bahan penebat. Sehubungan dengan itu, informasi mengenai penyebaran medan disekitar penebat voltan tinggi adalah amat penting bagi menentukan tekanan medan elektrik yang terbentuk di atas permukaan penebat, terutamanya di bahagian udara pada sempadan antara penebat dan udara. Oleh yang demikian, merujuk kepada perkara tersebut, projek ini akan menganalisa penyebaran medan elektrik bagi penebat getah silikon voltan tinggi. Bagi tujuan perbandingan, analisa yang dilakukan adalah berdasarkan kepad dua situasi, getah silikon yang mempunyai permukaan yang bersih dan getah silikon yang mempunyai lapisan bahan pencemar di sepanjang bahagian permukaannya. Selain daripada itu, kesan titisan air yang terdapat di atas permukaan penebat juga dirangkumkan. Pengiraan bagi sebaran medan elektrik pada permukaan penebat disempurnakan menggunakan perisian SLIM yang melaksanakan kaedah elemen tak terhinnga dua dimensi. Hasil daripada projek ini menunjukkan bahawa kehadiran lapisan pencemar memesongkan pengagihan voltan di sepanjang permukaan penebat sementara bahan pencemat yang berbeza serta variasi kepad zon yang terlibat akan menyumbang kepada profil medan elektrik yang berbeza. Kehadiran titisan air akan menghasilkan pertambahan medan di sempadan antara air, udara dan bahan getah silikon. Disamping itu, pertambahan tekanan medan yang dibentuk oleh titisan air adalah bergantung kepada saiz titisan, bilangan titisan dan jarak di antara satu titisan dengan titisan yang lain.

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LIST OF SYMBOLS / ABBREVIATIONS

D	-Distortion factor.
H	-Size of the element.
R	-Diameter of the largest circle in the element.
V	-Volt
m	-Meter
h_i	-Axial height
r_e	-Electrode radius
r_{ec}	-Electrode corner radius
r_i	-Core radius
r_{ic}	-Inner corner radius (the radius of curve fitting between shed and sheath)
r_o	-Shed radius
r_{oc}	-Outer corner radius (the radius of curve fitting between the upper and bottom shed)
E_{max}	-Maximum field at the surface
θ	-Shed slope angle (the slope angle of the upper shed)
ε	-Permittivity
^{o}	-Degree

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter would describe the overall overview of the project which includes the project objective, scope, project schedule and the outline of the thesis.

1.1 The Objective of the Project

The main objective of this project is to carry out a study on the electric field distribution of energized silicon rubber insulator under clean and contaminated condition using finite element method which is simulated by SLIM software.

1.2 The Scope of the Project

In order to limit this project under certain degree, the objectives of this project are assisted by certain scopes. Those scopes are as listed below:

a) To appreciate the application of two dimensional linear finite element numerical method in electric field calculation.

b) To observe and investigate the properties of silicon rubber.

c) To implement the finite element method technique using SLIM.

d) To model the contamination layer on the surface of silicon rubber insulator.

e) To study the electric field pattern of silicon rubber insulator under clean and contaminated condition of energized silicon rubber insulator.

1.3 The Project Schedule

This project was accomplished in two consecutive phases which are Project I and Project II where Project II is the continuation from Project I. The theoretical part is being covered mostly within the Project I timeframe while Project II depict the simulation analysis of the project. Those project schedules are given separately by Appendix A.

1.4 Thesis Outline

This thesis is being divided into six consecutive chapters where each chapter review different issues regarding to the project objectives. Chapter 1 covers the introductory section of the project while Chapter 2 and Chapter 3 described the literature review and theoretical background that related to finite element method and silicon rubber respectively. The following chapter is Chapter 4 where this chapter provides the explanation on project methodology used throughout the operation of the project. Simulation results and analysis is explained individually in Chapter 5 and the last chapter, which is Chapter 6, considers the future recommendations in extending the project into a better prospect.

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